Claims

1. An injector for fuel injection systems of internal combustion engines, in particular direct-injection diesel engines, having a piezoelectric actuator (16), which is contained in an injector body (10) and acted on by a first spring mechanism (35) so that it remains in contact with the injector body (10) at one end and with a sleeve-like booster piston (33) on the other; having a nozzle body (20), which is connected to the injector body (10) and has at least one nozzle outlet opening (26 – 29), and in which a stepped (first) nozzle needle (21) is guided in an axially movable fashion; having a second spring mechanism (54) that is contained inside the booster piston (33) and, together with the injection pressure acting on the rear end of the (first) nozzle needle (21), holds the (first) nozzle needle (21) in the closed position; and having an (outer) control chamber (47) that is embodied at the nozzle needle end of the booster piston (33) and communicates via at least one leakage gap with a fuel supply (18) under injection pressure; the fuel contained in the (outer) control chamber (47) acts on the (first) nozzle needle (21) in the opening direction (55); and a rear region (31) of the (first) nozzle needle (21), which has a larger diameter than a nozzle outlet region of the (first) nozzle needle (21), is fitted into the internal chamber (32) of the booster piston (33), characterized in that the first nozzle needle (21) has a concentric axial recess (39) passing through it, which is stepped by means of a shoulder (38) and has a second nozzle needle (41), which is likewise correspondingly stepped by means of a shoulder (40), fitted into it in an axially movable fashion; inside the axial recess (39) – between its shoulder (38) and the shoulder (40) of the second nozzle needle (41) – a (second) inner chamber (52) is formed, which is hydraulically connected to the (first) outer control chamber (47); and the control

chamber volumes and the surfaces of the nozzle needles (21, 41) – which are acted on by the control chamber pressures, the pressure of the fuel supply (18, 19), and the spring mechanism pressure – are matched to each other so that the two nozzle needles (21, 41) open in succession in response to a change to the electrical voltage applied to the piezoelectric actuator (16).

2. The injector according to claim 1,
characterized in that the fluid pressure-loaded surfaces of the second nozzle needle (41) in comparison to the fluid pressure-loaded surfaces of the first nozzle needle (21) are designed so that the second nozzle needle (41) opens at a comparatively low control chamber pressure (comparatively low piezoelectric actuator voltage), but the first nozzle needle (21) only opens at a comparatively high control chamber pressure (comparatively high piezoelectric actuator voltage).

3. The injector according to claim 1 or 2,
characterized in that the two control chambers (47, 52) communicate with each other hydraulically via a bore (53) passing obliquely through the first nozzle needle (21).

4. The injector according to one or more of the preceding claims in which the inner chamber (32) of the booster piston (33) is hydraulically connected to the fuel supply (18), characterized in that a third spring mechanism (56) contained inside the booster piston (33) acts on the piezoelectric actuator end (upper end) of the second nozzle needle (41) in the direction toward the closed position (arrow 55).

5. The injector according to claim 4 in which the spring mechanism that acts on the nozzle needle (21) in the closing direction (arrow 55) is a helical compression spring (54) that is situated coaxial to the first nozzle needle (21) and rests against its rear end surface at one end and at the other end, rests against the piezoelectric actuator end (upper end) of the internal chamber (32) of the booster piston,
characterized in that the third spring mechanism is also a helical compression spring (56), which is encompassed by and concentric to the second spring mechanism (helical compression spring 54) and which rests against the second nozzle needle (41) at one end and at the other end, rests against the piezoelectric actuator end (upper end) of the inner chamber (32) of the booster piston.

6. The injector according to claim 5,
characterized in that a shoulder (57) is provided at the piezoelectric actuator end (upper end) of the second nozzle needle (41), adjoined by a smaller-diameter pin piece (58), and the helical compression spring (56) serving as the third spring mechanism is placed onto the pin piece (58).

7. The injector according to one or more of the preceding claims in which, the nozzle outlet region of the nozzle body (20) contains a cylindrical pressure chamber (42) that concentrically encompasses the first nozzle needle (21) and is hydraulically connected to the fuel supply (18) under injection pressure (high pressure),
characterized in that the axial recess (39) of the first nozzle needle (21) through which the second nozzle needle (41) passes has a diametrical expansion in its nozzle outlet region

(lower region), thus producing an annular, cylindrical cavity (59) encompassing the second nozzle needle (41) in its nozzle outlet region (lower region), and the first nozzle needle (1) has at least one radial bore (60) let into it, which hydraulically connects the cylindrical pressure chamber (42) to the annular, cylindrical cavity (59).

8. The injector according to one or more of the preceding claims, characterized in that the nozzle outlet (61) of the nozzle body (20) has one or more radially outer nozzle outlet openings (28, 29) controlled by the first (outer) nozzle needle (21) and one or more radially inner nozzle outlet openings (26, 27) controlled by the second (inner) nozzle needle (41).

9. The injector according to one or more of the preceding claims, characterized in that the (lower) end region (61) of the nozzle body (20), which contains the nozzle outlet openings (26 – 29), and the end sections (62, 63) of the two nozzle needles (21, 41), which function as closing bodies, are embodied as conical so that when the nozzle needles (21, 41) are both in the closed position or open position, their end sections (62, 63) combine to form a single conical surface.